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The Occurrence of Plerocercoids of Diphyllobothrium spp. in Wild and Cultured Salmonids from The Loch Awe Area

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Introduction

Plerocercoids of *Diphyllobothrium* spp. are common parasites of salmoniform fish in the Holarctic and Palaearctic regions. There has been considerable taxonomic confusion concerning the identity of diphyllobothriid plerocercoids but recent work has suggested that four species may be present in fresh water habitats in North West Europe (Halvorsen, 1970; Bylund, 1973, 1975 a, b). Only *D. dendriticum* (Nitzsch) and *D. ditremum* (Creplin) are commonly recorded from the British Isles, where they are found mainly in fish from upland lakes (Kennedy, 1974).

The life-cycles of these species are similar. Adult worms are found in piscivorous birds. *D. ditremum* occurs in the genera *Gavia, Merganser, Phalacrocorax* and *Ardea* (Bylund, 1973) whilst D. *dendriticum* is found in gulls (Laridae) (Halvorsen, 1970). The first intermediate hosts of both species are cyclopoid copepods and the plerocercoids are found mainly, but not exclusively, in salmonids (Halvorsen, 1970; Bylund, 1973). Because of this type of life-cycle diphyllobothriids in fresh water are most abundant in lacustrine environments.

This report describes the occurrence of *Diphyllobothrium* spp. in cultured and wild fish from Loch Awe in western Scotland.

Materials and Methods

Inverliever fish farm is situated at the southern end of Loch Awe, Argyll (Fig. 1). The farm grows rainbow trout, *Salmo gairdneri* Richardson, in brick raceways using an unfiltered water supply pumped from the loch. In September 1975 trout of the 1973 hatch were processed on the farm and found to be infected with diphyllobothriid plerocercoids, and so some had to be rejected. Two groups of trout from the 1973 hatch were examined in detail. One group of 20 was dissected manually, whilst in the second group of 30 the flesh was digested using the method of Smith & Wootten (1975) except that digestion was carried out at 37°C. The viscera of these fish were deep-frozen and later dissected. In addition 25 trout of the 1974 hatch were examined by dissection.

Brown trout, *Salmo trutta* L., and rainbow trout were sampled from four sites in Loch Awe during May 1976 using sweep nets (see Fig. 1). Each fish was measured to the fork of the tail and its age determined by scale readings. The viscera of the trout were deep-frozen and later dissected. The flesh of these fish was not available for examination.

Char, *Salvelinus alpinus* (L.), were caught by gill net at the farm outlet in May 1976. The fork length of these fish was measured and their age determined by otolith readings. The whole bodies of the char were deep-frozen and later dissected.

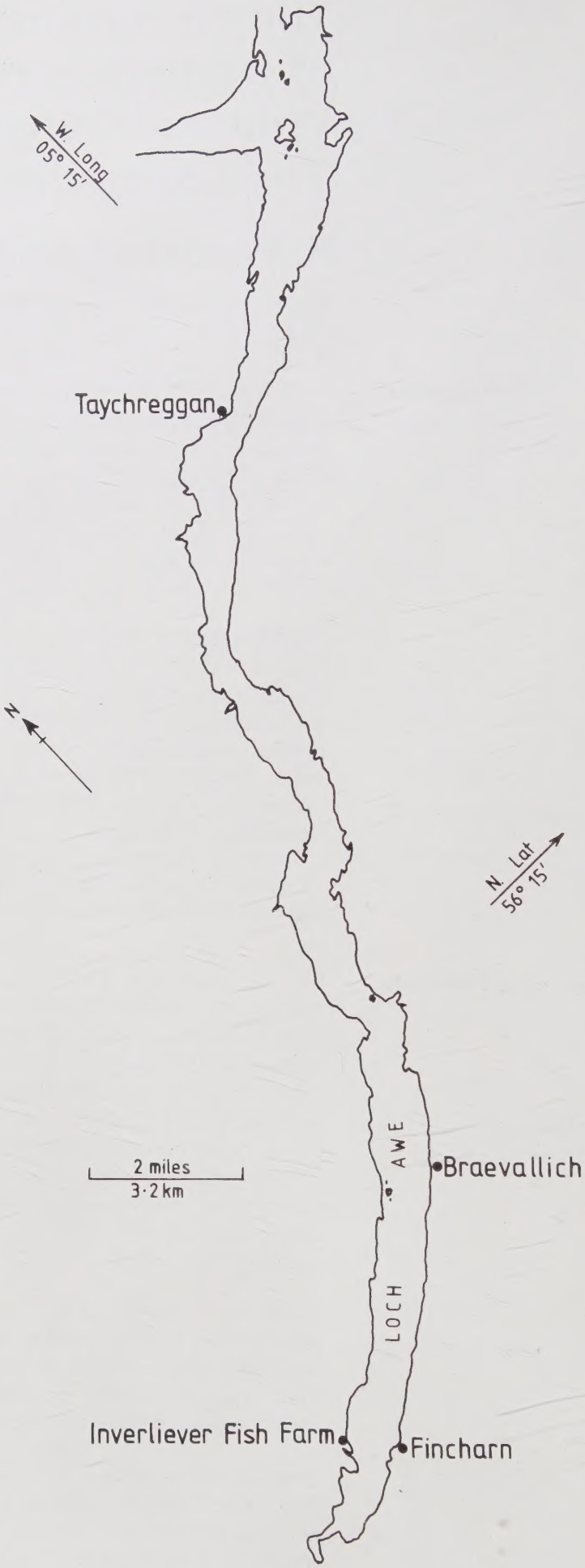

Figure 1. Southern stretch of Loch Awe showing the four sampling sites referred to in the text.

Results

Farmed Fish

The numbers of rainbow trout of the 1973 hatch from three different raceways which were rejected during processing because of the presence of diphyllobothriid cysts on the hypaxial muscles are shown in Table I. These cysts all contained plerocercoids of *D. dendriticum*.

Table I.

Numbers of 1973 hatch rainbow trout rejected during processing owing to the presence of *Diphyllobothrium* cysts

Raceway No.	No. of fish processed	No. of fish rejected	% of fish rejected
F2	7355	168	2.3
F3	3468	52	1.5
G3	1788	210	11.7

Seven of twenty (35%) of the first group of 1973 hatch trout examined were infected with diphyllobothriids. Two of these fish had a single cyst of *D.dendriticum* on the hypaxial musculature. In the second group of 1973 trout 11 of 30 examined (37%) were infected. Three of these fish had single *D.dendriticum* cysts on the hypaxial musculature. Infected trout contained a number of cysts on the stomach and among the pyloric caeca. The cysts were not counted but most plerocercoids from these sites were *D. ditremum*.

None of the 25 1974 hatch of trout examined were infected.

Wild Fish

Infection and age of fish

(a) Brown Trout

Brown trout of all ages from each of the sampling areas were commonly infected with both *D. ditremum* and *D. dendriticum*, although the former species was the more abundant. In general there was a rise in the level of infection with increasing fish age in all areas (Table II).

Table II.

The infection of brown trout of different ages and from different areas of Loch Awe with *Diphyllobothrium* spp.

			D. ditremum			*D. dendriticum*		
Area	Age	No. of fish examined	% of fish infected	Mean no. per fish	*S*	% of fish infected	Mean no. per fish	*S*
Farm	2	12	50.0	0.7	0.8	33.3	0.4	0.7
	3	35	57.1	1.4	2.0	51.4	0.9	1.1
	4	16	75.0	6.5	42.9	62.5	1.2	1.3
	5	11	90.9	10.2	9.2	81.8	2.5	2.0
	6	1	(100)	(47)	–	(100)	(1)	–
Braevallich	2	2	(50)	(1.5)	–	(50)	(0.5)	–
	3	14	78.6	4.2	5.8	85.7	1.4	1.0
	4	11	81.8	8.5	7.8	90.9	2.2	1.4
	5	2	(100)	(6)	–	(50)	(1)	–
Taychreggan	2	4	75.0	2.8	2.0	25.0	0.3	0.5
	3	8	100.0	11.8	13.2	75.0	1.6	1.3
	4	10	100.0	9.8	7.9	100.0	1.8	1.0
	5	2	(50)	(29)	–	(50)	(1)	–
Fincharn	2	11	27.3	0.3	0.5	18.2	0.2	0.4
	3	14	71.4	2.7	2.9	64.3	1.1	1.1
	4	8	100.0	6.5	6.4	75.0	1.3	1.2
	5	3	(100)	(5.7)	–	(66.7)	(1.3)	–

An analysis of variance was carried out to determine whether there were significant differences between the mean numbers per fish of *D. ditremum* and *D. dendriticum* in 3 and 4 years old trout from each of the sampling areas. The data for *D. dendriticum* in 3 years old trout were transformed using the $y = (x + 0.38)$ transformation. The analysis on 4 years old fish with *D. dendriticum* was performed on untransformed data. The data for *D. ditremum* in both 3 and 4 years old trout were transformed using $y = \log^{10} (x + 1)$. There was no significant difference between the area means for 3 and 4 years old fish infected with *D. dendriticum* or for 4 years old trout with *D. ditremum*. However, there was a significant difference between the area means for *D. ditremum* in 3 years old trout ($F = 8.50$, $P = <0.001$). A Duncan's Multiple Range Test was carried out to determine which of these means were significantly different. The log means for each area were:—

Farm	— 0.27
Braevallich	— 0.53
Taychreggan	— 0.93
Fincharn	— 0.44

The mean for Taychreggan was significantly higher than all other means. In addition the mean for Braevallich was significantly higher than that for the farm but neither differed significantly from that for Fincharn. The significant differences between area means are given below:—

Taychreggan — Farm	— 0.66
Taychreggan — Fincharn	— 0.49
Taychreggan — Braevallich	— 0.40
Braevallich — Farm	— 0.27

(b) Char

Char were infected with both species of *Diphyllobothrium*, although to a lesser extent than brown trout. Once again there was an increase in the level of infection with age of the fish (Table III).

Table III.

The infection of char of different ages with *Diphyllobothrium* spp.

Age	No. of fish examined	*D. ditremum* % of fish infected	*D. ditremum* Mean no. per fish	*D. ditremum* *S*	*D. dendriticum* % of fish infected	*D. dendriticum* Mean no. per fish	*D. dendriticum* *S*
3	17	58.8	0.8	1.0	23.5	0.3	1.1
4	15	73.3	1.4	1.3	6.7	<0.1	1.0
5	11	63.6	1.7	1.8	36.4	0.4	0.8
6 & 7	5	100.0	3.8	1.9	40.0	1.4	2.0

(c) Rainbow Trout

Sixteen 2 years old rainbow trout caught at the farm outlet were examined and two were found infected, each with a single plerocercoid of *D. ditremum*. The 2 years old rainbow trout from Braevallich were uninfected.

Association between D. ditremum and D. dendriticum

The association between *D. ditremum* and *D. dendriticum* in 3 and 4 years old brown trout was tested by means of 2 x 2 contingency tables (Table IV). There was a significant positive association between the two species such that double infections were more likely to occur than single species infections. However, there was no obvious association between the numbers of the two parasite species in individual trout.

Table IV.

The association of D. *dendriticum* and *D. ditremum* in 3 and 4 years old brown trout

3 years old trout

		D. ditremum		
		Absent	Present	Total
D. dendriticum	Absent	13	13	26
	Present	9	36	45
	TOTAL	22	49	71

$\chi^2 = 4.7$, $P = <0.05$

4 years old trout

		D. ditremum		
		Absent	Present	Total
D. dendriticum	Absent	4	5	9
	Present	2	34	36
	TOTAL	6	39	45

$\chi^2 = 6.4$, $P = <0.05$

Site of Infection

The location of plerocercoids found in brown trout and char is shown in Table V. Most plerocercoids of both species were encysted on the stomach or amongst the pyloric caeca. A significantly greater proportion of both species encysted on the stomach rather than the pyloric caeca (*D. ditremum* $\chi^2 = 39.7$, $P = <0.001$; *D. dendriticum* $\chi^2 = 4.5$, $P = <0.05$) although the proportion was much greater in *D. ditremum*.

Table V.

The site of infection of *Diphyllobothrium* spp. plerocercoids in brown trout and char (expressed as percentage of total number of plerocercoids found)

	Brown trout		Char	
	D. ditremum	*D. dendriticum*	*D. ditremum*	*D. dendriticum*
Stomach	76.8	51.3	75.7	31.3
Pyloric caeca	16.1	32.0	4.1	6.3
Intestine	2.6	2.7	8.1	6.3
Liver	1.8	5.3	0	12.5
Spleen	0.3	0.7	0	0
Gonad	0.8	1.3	4.1	6.3
Swimbladder	1.6	6.7	8.1	25.0
Body Cavity	0	0	0	12.5

In char *D. ditremum* was again found mainly on the stomach but only a few occurred amongst the pyloric caeca. *D. dendriticum* was rare in char but over half the plerocercoids found were encysted on the stomach or swimbladder.

Discussion

Despite their widespread occurrence in wild fish there are few records of *Diphyllobothrium* plerocercoids in cultured fish. Occasional infections of *D. dendriticum* in rainbow trout kept in raceways were reported by Wootten (1973). The infection of cultured fish in the present study must have resulted from the ingestion of infected copepods entering the farm via the unfiltered water supply. It would be extremely difficult to eradicate an infection of *Diphyllobothrium* on a fish farm; probably only increased filtration of the water supply would be effective.

The occurrence of *Diphyllobothrium* in farmed trout in Scotland has not been a widespread problem since few farms take their water supply from lochs. There is, however, increasing interest by fish farmers in the use of floating cages in freshwater lochs to increase fish production and it is probable that *Diphyllobothrium* spp. will occur in trout kept under such conditions. In the present case the infected trout had been in the farm for three summers in contrast to the usual two summers taken to reach marketable size. This extra time may have allowed infection to reach a level where plerocercoids became obvious to farm workers. Only *D. dendriticum* was of economic significance since this species alone was found to encyst on the hypaxial musculature. Any plerocercoids amongst the viscera would be removed during processing. A comparison of the numbers of infected trout noticed by farm workers and the numbers found by dissection and digestion suggests that the farm staff were very efficient at identifying infected trout.

Both *Diphyllobothrium* species were common in brown trout and char from Loch Awe although the latter host was rather less heavily infected. This probably reflects the much smaller size of the char, which were a very slow-growing population (R.B. Greer, personal communication). It is interesting that the rainbow trout taken from the loch contained so few plerocercoids but this may simply be due to the limited length of time the fish had been at liberty. All rainbow trout in Loch Awe are escapes from the fish farm.

An increase in the level of infection of fish with *Diphyllobothrium* spp. with age and size of the host was recorded by Meyer & Vik (1968) and Henricson (1977). This is presumably due to the longevity of plerocercoids and their continued acquisition by fish over several years. No evidence was found of any serious pathological effect of *Diphyllobothrium* spp. on any of the fish examined although mortalities of older brown trout due to heavy parasite burdens have been recorded from British lakes and reservoirs (Fraser, 1960; Hickey & Harris, 1947).

The level of infection of *D. dendriticum* in brown trout was apparently uniform between the areas sampled but there was some evidence that *D. ditremum* was more abundant in the most northerly sampling area. Such differences presumably depend on local ecological factors favouring transmission of the parasite.

The location of plerocercoids of both parasite species within the host is similar to that recorded by Henricson (1977). Although there were significant differences between the preferred sites of the two species, most plerocercoids were found in the anterior visceral mass, particularly on the stomach and closely associated pyloric caeca. Newly ingested parasites probably penetrate through the gut wall in this region and become encysted without further migration through the viscera. Halvorsen & Wissler (1973) found that

D. dendriticum plerocercoids fed to rainbow trout penetrated the stomach wall. In the present study *D. dendriticum* was found in a greater number of sites in host fish than *D. ditremum*. Henricson (1977) found a similar distribution in char whilst Bylund (1972) suggested that the pathogenicity of *D. dendriticum* to brown trout and coregonids depended on the amount of migration by plerocercoids through the viscera.

There was a positive association between the two parasite species such that infected trout were more likely to contain both rather than a single species. This may be because both species have copepod intermediate hosts and therefore a trout feeding on such food is likely to become infected with both species of *Diphyllobothrium*. Despite this association between the presence of the two species there was no evidence of any correlation between the numbers of the parasites in individual infections. This contrasts with the positive correlation recorded by Henricson (1977) for *D. dendriticum* and *D. ditremum* in char.

Summary

In September 1975, plerocercoids of *Diphyllobothrium ditremum* and *D. dendriticum* were found in rainbow trout on a farm at the southern end of Loch Awe. The presence of *D. dendriticum* cysts on the hypaxial musculature led to the rejection during processing of 1.5, 2.3 and 11.7% of the 1973 hatch trout from three raceways. Wild brown trout from four areas in the loch were commonly infected with *D. ditremum* and, to a lesser extent, with *D. dendriticum*. The infection level tended to increase with host age. Whilst the infection level with *D. dendriticum* was apparently uniform between areas, that with *D. ditremum* appeared to be higher at the most northerly area. Infected trout tended to contain both rather than a single species of *Diphyllobothrium* but there was no evidence of any correlation between the numbers of the parasites in individual infections. Wild char caught in the loch at the farm outlet were infected with both species but to a lesser extent than brown trout. Two of 16 escaped rainbow trout caught at the farm outlet harboured *D. ditremum*.

References

Bylund, G. 1972. Pathogenic effects of a diphyllobothriid plerocercoid on its host fishes. *Commentat. biol.* No 58, 11pp.

———— 1973. Observations on the taxonomic status and the biology of *Diphyllobothrium ditremum* (Creplin, 1825) *[= D. osmeri* (Von Linstow, 1878)*]*. *Acta Acad. åbo. Ser. B.* **33**, 1–18.

———— 1975a. Studies on the taxonomic status and biology of *Diphyllobothrium vogeli* Kuhlow, 1953. *Commentat. biol.* No 79, 22pp.

———— 1975b. The taxonomic significance of embryonic hooks in four European *Diphyllobothrium* species (Cestoda, Diphyllobothriidae). *Acta zool. fenn.* **142**, 1–22.

Fraser, P.G. 1960. The occurrence of *Diphyllobothrium* in trout, with special reference to an outbreak in the West of England. *J. Helminth.* **34**, 59–72.

Halvorsen, O. 1970. Studies of the helminth fauna of Norway XV: On the taxonomy and biology of plerocercoids of *Diphyllobothrium* Cobbold, 1858 (Cestoda, Pseudophyllidea) from north-western Europe. *Nytt Mag. Zool.* **18**, 113–174.

Halvorsen, O. and Wissler, K. 1973. Studies of the helminth fauna of Norway XXVIII: An experimental study of the ability of *Diphyllobothrium latum* (L.), *D. dendriticum* (Nitzsch), and *D. ditremum* (Creplin) (Cestoda, Pseudophyllidea) to infect paratenic hosts. *Norw. J. Zool.* **21**, 201–210.

Henricson, J. 1977. The abundance and distribution of *Diphyllobothrium dendriticum* (Nitzsch) and *D. ditremum* (Creplin) in the char *Salvelinus alpinus* (L.) in Sweden. *J. Fish Biol.* **11**, 231–248.

Hickey, M.B. and Harris, J.R. 1947. Progress of the *Diphyllobothrium* epizootic at Poulaphouca Reservoir, Co. Wicklow. *J. Helminth.* **22**, 13–28.

Kennedy, C.R. 1974. A checklist of British and Irish freshwater fish parasites with notes on their distribution. *J. Fish Biol.* **6**, 613–644.

Meyer, M.C. and Vik, R. 1968. Observations on *Diphyllobothrium sebago* plerocercoids in the fish hosts. *Proc. helminth. Soc. Wash.* **35**, 92–96.

Smith, J.W. and Wootten, R. 1975. Experimental studies on the migration of *Anisakis* sp. larvae (Nematoda: Ascaridida) into the flesh of herring, *Clupea harengus* L. *Int. J. Parasit.* **5**, 133–136.

Wootten, R. 1973. The metazoan parasite fauna of fish from Hanningfield Reservoir, Essex, in relation to features of the habitat and host populations. *J. Zool.* **171**, 323–331.

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